Letter from Alexander Graham Bell to Mabel Hubbard Bell, June 7, 1895, with transcript

ALEXANDER GRAHAM BELL TO MABEL (Hubbard) BELL Beinn Bhrengh Laboratory. Friday, June 7th, 1895. My darling May:

I am using the upper room in the Laboratory as a bedroom — so as to be on hand as early as possible after Mr. Ellis arrives in the morning. We have been occupied, since laboratory material arrived from Boston, in preliminary experiments. Was not quite satisfied with arrangement of apparatus. Think we have improved it very much — and hope tomorrow may prove to be the last day of preliminary work.

Experiments abundantly show — that increase of weight at circumference of apparatus — yields an increased lift at same speeds of rotation — but I am not at all satisfied that this is due to the inertia of the added mass. If the momentum or rather energy, of the added mass is the cause — I should expect that the difference of lift would to greater with high speeds of rotation than with slow — but my experiments do not as yet give conclusive evidence on this point.

What I should expect if the kinetic energy of the mass is the cause of the increased lift.

What I sees to get.

The curves seem to be parallel or rather — the difference of lift at the same speeds seems to be constant.

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This result — looks as though we had the same curve in the two cases — the effect of the load seeming simply to displace the curve to the left.

This has suggested the idea that the effect may be due to a displacement of the centre of gravity of each arm of the machine by the added weight.

In calculating velocities I have measured the speed of the motors in traversing the path shown by dotted line. Suppose this path to be 100 feet — and the machine to complete one rotation in one second. Then the motor velocity is 100 feet per second. Under these circumstances, (the motors acting upwards at an angle of 45°) the rotating machine becomes (apparently) lighter by a certain amount (say 500 grammes). This I call the “lift.” Now if I attach heavy weights at W — and again cause the machine to rotate once a second — the “lift” is greater than before (say 550 grammes.) The fact is undoubted — and abundantly verified by experiment.

As the framework carrying the motors has considerable 3 weight (weights W removed) the centre of gravity of each arm is not at the end where the motor is — but at some point nearer the centre. Then the weights (W) are removed — suppose the centre of gravity of each arm to lie at the point marked (A). Then the circular path pursued by the centre of gravity — is smaller than the dotted line. (say 50 feet). Then when the apparatus makes one rotation per second — the velocity of the centres of gravity is only 50 feet per second though the motor velocity is 100 feet per second.

Now put on the weights (W). The effect will be to displace the centres of gravity and cause them to fall further out on the area — (say at the points marked B). The circular path of the (B) points is evidently larger than that of the (A) point. Let it measure 60 feet in circumference. Then when the apparatus rotates once per second. The velocity of the centres of gravity is 60 feet per second when the weights are used (B) and 50 feet when the apparatus is unloaded (A).

Loading the apparatus at the circumference increases the velocity of the centres of gravity at the same speed of rotation.

Can this be the cause of the increased lift? Should not the velocity ascribed to each arm — be the velocity of its centre of gravity. It is obvious that with equal speeds of rotation — the velocity of the centre of gravity will be greater — when the centre of gravity is further out on the arm than when it is nearer the axis of rotation — and if this is the effective velocity the lift should be greater — and greater 4 in such a way as to cause a displacement of the curve similar to that shown on the second diagram on page 1. I have thought of an experiment to test the matter conclusively.

If the Kinetic energy of the added weight — is an element in increasing the lift — then it matters not where on the arm the weight is placed — (so long as it is not in the axis of rotation) — it should, anywhere on the arm, have Kinetic energy, and should therefore increase the lift . The effect should be less as the weight approaches axis of rotation because its energy of movement is less — but anywhere (not at the axis) it should have some motion — and therefore to that extent should increase the lift. Let C be the place of the centre of gravity of each arm. Now place your weights (W) nearer the axis than C. In this position — if the Kinetic energy — is the effective cause — the lift should be increased as before (but not to the same extent). Whereas if the displacement of the centre of gravity is the cause — the lift should be less than with the unloaded apparatus. This is a sort of experimentum crucis. In latter case also if weights are placed at the centres of gravity the lift should be unchanged.

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The question naturally arises — where on the arm is the centre of gravity? This is the point I am now trying to settle. I must confess that I have not sufficient mathematical skill — to calculate the location — and as the four arms are equally balanced — the centre of gravity of the whole apparatus falls in the axis of rotation and I see no way of ascertaining experimentally the centre of gravity of each arm — at least upon the apparatus itself. To meet the difficulty I have had Mr. Ellis make an exact copy of one of the arms. It looks something like this.

The centre of gravity lies at the point of intersection of the two lines ac, bd. We are in this way, experimentally ascertaining the exact position of the centre of gravity of an isolated arm under various conditions. We shall apply the knowledge gained — to the machine — and assume that under 6 similar conditions the centres of gravity of the different arms — lie in similar positions.

I hope to be able to arrange the apparatus so that the centres of gravity of the different areas will always be in the same places — under all circumstances of experiment — and I want to arrange matters so that the centre of gravity coincides with the centre of the wing-space.

Instead of putting motors and weights and etc., — away out at the end of the arm — I propose to put a cross-bar for motors at above centre — and use two motors (at least) on each arm.

Everything to be arranged so as not to displace the center of gravity from the centre of the wing-space. This I consider to be the most important improvement we are making in 7 the apparatus. There are a number of other points — but of minor importance. These changes however involve time — and delay the commencement of series experiments. I don't want to go on with these until I am satisfied with the apparatus itself. Then we will go ahead and do something with it.

This letter is so long that I have no time to write of other things — and will only copy a list of topics in my note-book headed “Items for Mabel — June 6th, 1895, at B.B.”

“Wild flowers of Canada. Srs. Hobart has a baby. Yesterday's club. Programme. (McInnis' automatic gate. McAuley's propeller. Nezico. Mr. Ellis' snake story. A.G.E's snake stories. Rocking-chair Fan. Horse-holder. Submarine volcano in the Atlantic. Argon and Helium. Argon and Bengene vapor and Aurora.) Sheep and lamb for Mr. McCurdy. Lambs all in. 24 (four-nippled) 2 (three-nippled) 0 (2-nippled). Sir Francis Galton's inquiry. Centre

of gravity experiments. With same rotations greater mass gives greater lift. Perhaps due to displacement of centre of gravity. Place working (calculations) inside zig-zag pages. Ferris-wheel arrangement in Earl's Court. Spherical telescope — done floating on water. Heteoric ring of Saturn. Identity of level of Baltic, Black and Azore seas. Deer and Kangaroo (deer frightee almost to death by dogs, not alarmed, only curious, at hopping of kangaroo). Oysters and Typhoid. Artificial wood for British men of war. Tan-spots over dog's eyes. Fire alarm — McInnis five minutes."

Have no time to expand these topics. In relation to 8 last will only say that Mr. McCurdy and I gave Mr. McInnis a fire alarm test — by ringing him up by telephone and telling him to come at once and put out the imaginary fire. He rode up to the Point in haste — and had a stream of water on the top of the house — in exactly five minutes from the time he was called! Pretty good wasn't it? He happened to have a horse and buggy at door — and drove away like mad — without a word to his wife! We had to telephone, her that everything was O.K. — and that there was no fire — only a test.

Your loving husband, Alec.